Towards less amputations in diabetic patients

Incidence, causes, cost, treatment, and prevention—a review

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Submitted 94-05-24. Accepted 94-11-01

Foot problems frequently threaten limb and life in the diabetic individual (Connor 1987, Greenhalgh et al. 1988, Fylling and Knighton 1989, Levin et al. 1993, Boulton et al. 1994). More than half of all amputations in the lower leg are performed in diabetic patients, mainly because of peripheral neuropathy, vascular disease, and infection. Two thirds of the amputations in diabetic patients are precipitated by a traumatic foot ulceration. A major amputation in diabetic patients is associated with a high morbidity, a high risk of further amputation and a mortality of 30–50 percent within 3 years. Annual short-term costs for lower leg amputation in diabetes approach the costs of treatment of patients with hip fracture or knee and hip arthroplasties together.

A multidisciplinary treatment of diabetic foot lesions improves the outlook for primary healing. Several studies have suggested that a program for preventive foot care and a multidisciplinary and multifactorial treatment by a foot-care team can reduce the amputation rate by more than 50 percent.

This review confirms that the incidence of major amputations in diabetic patients can be substantially reduced by a combined effort by all those involved in the treatment through a comprehensive system including regular foot examinations, preventive foot care and protective footwear, patient and staff education, a multidisciplinary approach to established foot lesions, strict amputation criteria, a long-term follow-up after healing, and a continuous registration of minor and major amputations.

Background

In 1991, WHO (Europe) and the International Diabetes Federation (IDF, European Region) accepted a program for improved diabetes care—the Saint Vincent Declaration (Molinatti and Porta 1990, Adamson et al. 1991). Certain goals were set up to reduce the incidence of the commonest diabetic complications. One of these goals is to achieve a reduction of 50 percent or more in major lower extremity amputations caused by diabetic gangrene. This review summarizes the problem of amputation in diabetic patients—prevalence, incidence, prevention, and treatment strategies—and analyzes the possibilities for achieving a substantial reduction in the major amputation rate.

Definitions

Amputation: resection of a part of an extremity, including its distal end.
Primary amputation: the first amputation procedure in a sequence until a final outcome (healing or death).
First event amputation: the first primary amputation in an individual in a certain period, irrespective of side and level of amputation.
Reamputation: amputation of an extremity with an unhealed previous amputation.
New amputation: amputation of an extremity with a healed previous amputation.
Bilateral amputation: simultaneous amputation of both lower extremities, irrespective of amputation level.
Second leg amputation: major amputation in a patient who has had a previous amputation of the contralateral leg.
Minor amputation: amputation through or below the ankle.
Major amputation: amputation above the ankle (below the knee or higher up).

Epidemiology

Ideally, the incidence of amputation should reflect

Table 1. Percentage of patients with diabetes in Scandinavian reports on amputation

Period	Country	Authors	n	Diabetes, percent
1949–59	Sweden	Alffram and Holmqvist	125	49
1947–61	Sweden	Hansson	269	53
1959–65	Denmark	Lindahl and Bolund	183	40
1967–69	Sweden	Hierton and James	94	60
1961–71	Denmark	Christensen[1]	326	46
1966–71	Sweden	Persson and Sundén	143	37
1971–77	Sweden	Borssén and Lithner[2]	95	56
1973–77	Sweden	Renström[3]	183	54
1976–79	Denmark	Helm et al.	231	24
1979	Sweden	Liedberg and Persson[4]	161	37
1971–80	Sweden	Lindegård et al.	351	52
1980–82	Sweden	Kald et al.	104	46
1978–84	Finland	Siitonen et al.[5,6]	477	53
1984–85	Finland	Pohjalainen and Alaranta[5]	705	46
1984–86	Sweden	Larsson and Risberg	241	50
1976–87	Sweden	Persson et al.[1,2]	1870	31–42 *
1987	Sweden	Eneroth and Persson[4]	177	40
1980–89	Denmark	Ebskov[7]	4852	30–20 **
1989	Finland	Lääperi et al.	268	47
1982–93	Sweden	Larsson et al.[5]	811	48

Unless otherwise stated, figures refer to amputations above the ankle, except those for trauma and tumor.
1 Syme's amputation and higher
2 All diagnoses
3 Below-knee amputations only
4 Diet-treated diabetes not included
5 Toe amputation and higher
6 First event amputations only
7 Transmetatarsal level and higher
* lowest and highest incidence during the time period
** first and last year in the time period

Table 2. Percentage of patients with diabetes in reports from outside Scandinavia on amputation

Period	Country	Author	n	Diabetes, percent
1964	USA	Warren and Kihn[1,2]	3962	39
1964–70	USA	Burgess et al.	193	52
1965–71	USA	Weaver and Marshall	105	31
1971–73	USA	Mooney et al.	190	66
1974–78	USA	Finch et al.	133	32
1976–78	USA	Most and Sinnock[2,3]	–*	45
1978–80	Singapore	Tan et al.	262	59
1979–81	USA	Miller et al.[2]	1448	63
1972–84	USA	Nelson et al.	84	95
1976–86	UK	Stebbings and Wood[4]	4852	24
1986	UK	Gregory-Dean[4]	4586	22
1979–87	Brazil	de Luccia et al.	128	52
1982–87	USA	Valway et al.[2]	1474	85
1987–88	Canada	Lawee and Csima	926	45
1988	USA	CDC[2]	1087	50
1965–89	UK	Stewart et al.[4,5]	1464	30
1987–90	USA	Lee et al.	110	40
1989–91	UK	Deerochanawong et al.[2,6]	285	39

Unless otherwise stated, figures refer to amputations above the ankle, except those for trauma and tumor.
1 Males only; patients with palpable pulse and/or secondary healing excluded
2 Toe amputation and higher
3 All diagnoses
4 Only includes patients referred for limb-fitting
5 Mid-foot and higher
6 Amputated patients
* Number of amputations not stated

the number of primary amputations in 100,000 inhabitants. However, most general health care records allow differentiation neither between primary amputations and re-amputations nor between first-event amputations and new amputations. In most studies, the number of amputations is based on in-hospital records from the Departments of Orthopedics and/or Surgery. There are few population-based studies.

Commonly, incidence figures reflect only below-knee or higher amputations. During recent years more studies include amputations below the ankle (Tables 1–3).

Incidence figures commonly reflect the number of amputations caused by vascular disease and/or diabetes, thus excluding amputations caused by tumors, trauma, malformations and some other diagnoses, such as foot deformity not related to diabetes or vascular disease. These diagnoses usually make up 5–15 percent of the total number of amputations of the lower extremity (Warren and Kihn 1968, Burgess et al. 1971, Weaver and Marshall 1973, Liedberg and Persson 1983, Helm et al. 1986, Larsson and Risberg 1988, Nelson et al. 1988, Pohjalainen and Alaranta 1988, Persson et al. 1989, Ebskov 1991, Gregory-Dean 1991, Stebbings and Wood 1991, Moss et al. 1992, Stewart et al. 1992, Valway et al. 1993). In some reports, amputations caused by vasculitis, leg ulcers, and/or thromboembolic disease are defined as non-vascular (Warren and Kihn 1968, Waugh 1988, Stewart et al. 1992, Siitonen et al. 1993).

In the classification of amputations, three main groups emerge: patients with vascular disease without previously known diabetes, patients with diabetes mellitus with or without vascular disease, and patients with tumor, trauma, foot deformity, and other conditions not related to diabetes or vascular disease. The first two groups are usually used for calculations of the incidence. They provide the basis for the following presentation.

Table 3. Incidence of amputation in patients with diabetes in population-based reports

Period	Country	Area/population	Per 100,000 inhabitants	Per 1,000 individuals with diabetes
1976–78	USA	6 states in M.W.[1,2]	–	5.9
1979	Sweden	Malmöhus county[3]	11.9	–
1971–80	Sweden	Gotland	20.5	–
1971–80	Sweden	Umeå[4]	13.8–3.1	–
1979–81	USA	New Jersey[1]	–	7.7
1980–82	UK	Tayside[5,6]	–	10
1972–84	USA	Pima Indians[1,7]	206	14–24
1978–84	Finland	Kuopio[1,7]	10.1	4.8
1984–85	Finland	Helsinki[1,7]	12.3	–
1980–86	USA	Wisconsin[1,8]	–	5.5
1980–87	USA	CDC	–	8.2
1982–87	USA	4 Indian areas[1,9]	–	7.4–24
1987	Sweden	Malmöhus county[6,10]	10	–
1987–88	Canada	Ontario	–	4.4
1980–89	Denmark	National[11,12,*]	11–7	–
1989	Finland	Helsinki[1,7]	10.1	–
1989	Sweden	National **	11.5	
1989–91	UK	Newcastle upon Tyne[1,5]	5.7	5.7[13]
1982–93	Sweden	Lund/Orup[14,12]	16.1–3.6	6.7–1.5[15]
-"-	-"-	Lund/Orup[1,14,12]	19.1–9.8	7.9–4.1[15]

Unless otherwise stated, figures refer to amputations above the ankle, excluding those for trauma and tumors.

* The Danish Amputation Register
** The National Swedish Board of Health and Welfare
1 Toe amputation and higher
2 All diagnoses included
3 Diet-treated diabetes not included
4 Rural and urban area, respectively
5 Number of amputated patients
6 Syme's amputation and higher
7 First amputations in the time period only
8 Cohort study
9 Lowest and highest incidences during the time period
10 Primary amputations
11 Transmetatarsal level and higher
12 First and last year
13 Calculation based on a diabetes prevalence of 1 percent
14 Primary amputations according to final level
15 Calculation based on a diabetes prevalence of 2.4 percent

Diabetes mellitus in non-Scandinavian studies

The percentage of amputations in patients with diabetes mellitus was reported to be 22–95 percent in studies from outside Scandinavia during 1964–1991 (Table 2). The highest percentage with diabetes mellitus was reported from the USA in regions with certain Indian tribes having a very high prevalence of Type 2 diabetes mellitus (Nelson et al. 1988, Valway et al. 1993). The lowest percentage of diabetes mellitus among patients undergoing leg amputation was reported from the UK and was based on prosthetic rehabilitation registers (Gregory-Dean 1991). If these reports are excluded, the proportion of diabetes mellitus in studies of leg amputation was between one and two thirds.

Diabetes mellitus in Scandinavian studies

The percentage of amputations in patients with diabetes mellitus in Scandinavian reports has been estimated at 20–60 percent (Table 1). The lowest percentage is reported from Denmark (Helm et al. 1986, Ebskov 1991).

In Sweden, the corresponding figures are 31–60 percent (Tables 1 and 4). According to official national statistics, the figures were 39 and 43 percent in 1989 and 1991, respectively, based on first diagnosis and first amputation code (In-patient statistics, The National Swedish Board of Health and Welfare 1989 and 1991, respectively; Table 4). In a pilot study (The National Swedish Board of Health and Welfare 1993), a continuous prospective registration of amputations in two counties in central Sweden showed that 57 percent of them were performed at

Table 4. Lower extremity amputations in Sweden

Level	1983[1]	1986	1989		1991	
	n	n	n	DM%[2]	n	DM%[2]
Toe	804	624	638	55	546	62
Midfoot	139	135	147	68	114	74
Syme	34	36	35	–[3]	42	54
Below knee	1746	1888	1852	41	1561	47
Through knee	215	331	278	31	335	28
Above knee	1320	1032	944	23	759	24
Total	4258	4046	3894	39	3357	43

n indicates number of amputations
Source: In-patient statistics, the National Swedish Board of Health and Welfare
1 Calculated number based on 80 percent of the admissions
2 Percentage of patients with diabetes, excluding those who had amputations for trauma and tumor, based on main diagnosis ICD-9 numbers 250 or 440–459
3 No information available

Table 5. Annual number of amputation procedures (primary amputations and re-amputations) in the Department of Orthopedics, University Hospital of Lund, in the official register and in a specific, continuous registration

	Specific registration	Official registration	
	n	n	Percent
1982	176	101	57
1983	163	114	70
1984	151	98	65
1985	162	109	67
1986	141	92	65
1987	141	106	75
1988	124	84	68
1989	98	70	71
1990	87	54	61
1991	124	60	48
1992	96	52	56
1993	109	57	52
Total	1572	997	63

n indicates number of operations.

all levels in patients with diabetes mellitus. Thus, although there are many differences concerning the design for the registration and of study of the percentage of diabetic patients undergoing amputation, available information indicates that half of the primary amputations at all levels (tumor, trauma and foot deformity excluded) are performed in diabetes mellitus cases. The proportion of diabetic patients varies substantially with, and is inversely related to, the amputation level (Borssén and Lithner 1984, de Luccia et al. 1992, Valway et al. 1993). Therefore, when discussing diabetes and amputation, minor amputations should be included in the evaluation.

Population-based studies

The number of population-based studies is limited (Table 3). In most studies, the incidence is reported as number of amputations/100,000 inhabitants per year and has been estimated at 7–206. The highest figures are reported from the USA in the previously mentioned Indian tribes (Nelson et al. 1988, Valway et al. 1993) and the lowest incidence is reported from Denmark and the United Kingdom (Helm et al. 1986, Ebskov 1991, Gregory-Dean 1991, Stebbings and Wood 1991, Deerochanawong et al. 1992). The best way to describe the situation would be to calculate the number of primary amputations/1,000 diabetic patients/year. However, this is usually not possible because the prevalence of diabetes mellitus is not known. Available information indicates an incidence of 5–24 and most commonly 6–8/1,000 diabetic patients/year (Table 3).

Problems concerning registration of amputation

In most reports, both the number of amputations and the diagnosis of diabetes are underestimated. In the Lund/Orup health care district in southern Sweden (population 0.2 million), a continuous registration of all amputations was performed and compared with the official in-patient register. During the period 1982–1993, 63 (48–75) percent of all amputation procedures performed on the lower extremity were entered into the official register (Table 5). Only 36 percent of the diabetes-related amputations were noted in the official register. This finding is in agreement with previous reports (Most and Sinnock 1983, Lindegård et al. 1984, Waugh 1988, Leslie et al. 1992). Another key problem concerning the national health care registration is that it is usually not possible to distinguish between a primary amputation and a re-amputation, nor is the cause of amputation registered as such (Most and Sinnock 1983).

In most studies, the diagnosis of diabetes is defined as previously known diabetes. In Western countries today, 15–19 percent of all diabetic patients undergoing amputation are diagnosed only at the time of amputation (Ecker and Jacobs 1970, Deerochanawong et al. 1992), indicating the need for routine screening for diabetes in all cases of amputa-

tion because of vascular disease.

Even when known, the diagnosis of diabetes is in many cases not recorded when the patient is discharged from hospital after amputation (Lindegård et al. 1984, Leslie et al. 1992). Another reason for underestimation of the amputation incidence in patients with diabetes mellitus is that some patients treated with diet only are not classified as having diabetes (Liedberg and Persson 1983, Eneroth and Persson 1992), resulting in the exclusion of 6–17 percent of diabetic patients with amputation (Deerochanawong et al. 1992, Larsson et al. 1993, Larsson 1994). A further reason is that some studies report on the number of amputated patients rather than on primary amputations (Deerochanawong et al. 1992). These observations highlight the need for a continuous and specific registration of amputations on a national basis, both in diabetic and non-diabetic patients, irrespective of amputation level.

Why do diabetic patients undergo an amputation?

The commonest reason why a diabetic patient requires an amputation is a foot lesion, deteriorating to deep infection and/or gangrene (50–70 percent; Palumbo and Melton 1985, LoGerfo et al. 1992, Larsson et al. 1994a). The latter figure was found in a continuous amputation registration in southern Sweden during 1982–1993, where the majority of the patients had been followed prospectively.

The principal underlying condition preceding the foot ulceration is polyneuropathy with sensory, motor and autonomic disturbances, reported in 70–100 percent of diabetic patients with foot ulceration (Ctercteko et al. 1981, Delbridge et al. 1983, 1985, Boulton et al. 1986, Edmonds 1986, Boulton 1988, Nelson et al. 1988, Sims et al. 1988, Apelqvist et al. 1990a, Deerochanawong et al. 1992, Rith-Najarian et al. 1992, Larsson et al. 1994b). Usually, the foot ulceration is precipitated by trauma, most often caused by faulty or incorrectly used footwear (Apelqvist et al. 1990a). However, some ulcerations are caused not by polyneuropathy but by direct manifestations of a concomitant peripheral vascular disease. The pathways leading to the development of foot lesions in diabetic patients, and consequently the risk of amputation, have been reviewed (Pecoraro et al. 1990, Reiber et al. 1992) and 3 main groups of diabetic patients with a high probability for an amputation have been defined: patients with polyneuropathy, without evidence of vascular disease, patients with polyneuropathy and vascular disease, and patients having vascular disease without evidence of polyneuropathy. The proportion between these groups varies from study to study, owing to the selection of patients and to demographic differences.

The possibility of healing foot ulcers in diabetic patients is limited by multiple factors: multiple types of cardiovascular disease, especially congestive heart failure, infection, type and site of lesion, metabolic control, microangiopathy, compliance, and degree of peripheral vascular disease, the latter being the main factor (Lithner 1974, Lithner and Törnblom 1984, Sims et al. 1988, Bild et al. 1989, Apelqvist et al. 1989a, b, 1990b, 1992, Frykberg 1991, Apelqvist and Agardh 1992, Levin et al. 1993).

In diabetic patients, severe peripheral vascular disease does not always present with rest pain or claudication (Thomas et al. 1988, Apelqvist et al. 1992). Therefore, even in the absence of these signs, non-invasive vascular testing, such as systolic toe and/or ankle pressure measurements (Karanfilian et al. 1986, Apelqvist et al. 1989a, Second European Consensus Document 1991) should be carried out in all diabetic patients with foot lesions, to identify those needing vascular intervention. No diabetic patient should undergo amputation without a preceding vascular evaluation concerning this possibility (Frykberg 1991, Second European Consensus Document 1991, Levin et al. 1993).

Indications

The indications for amputation in patients with diabetes mellitus are often multiple, which is well illustrated by various studies of diabetes-related amputations (Fylling and Knighton 1989, Larsson et al. 1994b; Table 6). The indications most commonly cited, were gangrene (84 percent), infection (63 percent), and non-healing ulcer (55 percent). This illustrates that many diabetic patients undergoing amputation have a foot ulcer and also the importance of describing indications and reasons for amputation. In retrospective studies, the proportion of diabetic patients who had gangrene at the time of amputation was estimated to be 50 percent (Mooney et al. 1976, Sage 1987, Akanji et al. 1988). In a corresponding prospective study (Larsson et al. 1994b), 70 percent had gangrene at the time of amputation. No prospective study, evaluating the immediate, precipitating cause of amputation in diabetic patients, has yet been published.

Table 6. Summary of 38 authors' criteria for amputation. Modified after Fylling and Knighton (1989)

Criterion		n
1	Gangrene	32
2	Infection	24
3	Non-healing ulcer	21
4	Ischemic pain	12
5	Osteomyelitis	10
6	Local necrosis	7
7	Systemic toxicity	6
8	Acute thrombembolic disease	5
9	Trauma	5
10	Tumor	4
11	Bürger's disease	4
12	Malformations	4
13	Bone or tendon exposed	3
14	Vasculitis	2
15	Intermittent claudication	1
16	Improve function	1
17	Hygienic problems in debilitated patient	1

n indicates number of reports

Cost for amputation in diabetes mellitus

The direct cost of an amputation in the USA (1984), including hospitalization, surgery and anesthesia, has been estimated at USD 8,000–12,000 or USD 500 millions/year for all amputations in the diabetic population, rehabilitation not included (Bild et al. 1989, Fylling and Knighton 1989). The corresponding cost for amputation in patients with or without diabetes, including rehabilitation, has been estimated at USD 27,000 and USD 40,000 in 1981 and 1984, respectively (Mackey et al. 1986, Gupta et al. 1988). In a recent report (Gibbons et al. 1993), the authors estimate the cost of amputation at USD 18,300 in 1990 currency value (hospital treatment only included). In the UK, the corresponding figures for the immediate cost of the major amputations in diabetic patients, including fitting of artificial limbs, was £ 8,500 sterling/amputation, and £ 13.4 millions sterling annually, updated to 1985–86 (Connor 1987).

In Sweden, foot lesions have been reported to be the most important complication in diabetic patients, accounting for about 25 percent of the cost of the in-patient care (Jönsson 1983). Most of these reports are based on retrospective data on patients, include in-hospital cost only and do not follow the patient from admission until healing is achieved.

In a prospectively studied group of patients, a retrospective economic analysis was performed, including the costs of both in- and out-patient treatment given by a foot-care team until healing after amputation, rehabilitation included (Apelqvist et al. 1994a). The cost for diabetic patients with foot ulcer was estimated at SEK 344,000 (SEK 258,000 and SEK 390,000 for minor and major amputations, respectively; 1990 currency). 26 percent of the costs were caused by treatment strategies prior to amputation. These patients have been followed prospectively after healing. Costs related to foot problems, including preventive foot care, vascular surgery, re-ulceration and subsequent amputation during the first 3 years after healing were estimated at SEK 258,000 in patients with minor amputation and 378,000 in patients with major amputation (1990 prices; Apelqvist et al. 1994b). The predominant costs during these 3 years of observation were costs related to home care and social service. In a follow-up study (Mackey et al. 1986) of 106 patients (diabetes status not reported), treated for limb-threatening ischemia at a New England medical center, the average cumulative cost of care was USD 40,000 for an amputation with a follow-up for an average of 1.8 years.

In patients who had had an amputation, two thirds of the average number of treatment days in hospital after an amputation were spent in departments other than that of orthopedics, i.e., internal medicine or infectious diseases, or in nursing homes (Apelqvist et al. 1994b). Thus, when estimating costs of in-patient care, not only admission in surgical departments must be included, but also in various medical departments and institutions. These factors probably explain the great variation concerning hospital stay in the different studies presented (Jönsson 1983, Mackey et al. 1986, Callow and Mackey 1988, Gupta et al. 1988, Raviola et al. 1988, Persson 1989, SBU 1990, Lithner 1991, Leese 1992, Apelqvist et al. 1994a). It is important that not only the costs of hospitalization and rehabilitation but also the out-patient treatment costs until healing are included when evaluating costs of amputation or other therapeutic strategies. However, comparisons of costs between different strategies of treatment are difficult since most studies are retrospective and the groups are not comparable regarding age, sex, and vascular disease. The proportion of minor and major amputations and the use of angioplasty and reconstructive vascular surgery also varies as also does the estimation of costs. Moreover, most previous studies did not distinguish between diabetic and non-diabetic patients or between patients with foot ulcer and patients who have had an amputation for other reasons.

Therefore, amputation is a costly solution to the problem of diabetic foot ulcer and often results in multiple and prolonged hospitalization. Allowing for an underestimate of the number of amputations as

well as of the proportion of cases of diabetes, the costs in Sweden for amputation in diabetic patients are comparable to the costs for hip fracture or knee and hip arthroplasties combined (Bengtson et al. 1989, The National Swedish Board of Health and Welfare 1989, 1991, Borgqvist et al. 1991, Apelqvist et al. 1994a, b).

Strategy for treatment of diabetic patients with foot ulcers

A first step to minimize the risk of amputation is to prevent lesions that might precipitate the development of gangrene and/or a deep infection. The most important regimen is a regular inspection of feet and footwear among diabetic patients at their health care visits. However, previous studies have shown that regular examination of feet is carried out in only 12–15 percent of all diabetic patient check-ups and that the percentage of feet examined varies with the type of staff (Cohen 1983, Bailey et al. 1985).

These findings have recently been confirmed by studies in 300 diabetic patients in each of two areas in Sweden, presented in reports by the National Swedish Board of Health and Welfare (1992a, b). More than half of the diabetic patients had not had their feet or footwear examined during the 12 months immediately preceding examination.

Inspections of feet and footwear should include recording the presence of signs of polyneuropathy, impaired circulation, edema, deformities, cracked or dry skin, callosities, and pressure points. The patients should have access to preventive and medical foot care and adequate footwear.

However, once a diabetic patient has developed a foot ulcer, these strategies are not sufficient. Comprehensive knowledge of diabetes care, medical angiology, vascular surgery (angioplastic or reconstructive procedures), orthopedic surgery, orthotic technique, infection control and topical treatment are required to deal with this situation. It is generally agreed that these patients should have early access to a multidisciplinary team for examination and treatment, both as in- and out-patients. The team should make a coordinated evaluation of potential limiting factors for healing and should institute optimal strategies to achieve healing.

Non-invasive angiological evaluation and vascular surgery are often required. Strict amputation criteria have to be maintained and every patient should be followed until final outcome. After healing, whether primarily or after amputation, diabetic patients run a 50 percent risk of developing new ulcerations (Apelqvist et al. 1993).

Table 7. Areas reporting effect of intervention

Area	Country	Author	Reduction* percent
Memphis*	USA	Runyan 1975	68
Atlanta	USA	Davidson et al. 1981	49
Umeå**	Sweden	Lindegård et al. 1984	68
Geneva	Switzerland	Assal 1985	85
Kings College	UK	Edmonds et al. 1986	50
Tucson	USA	Malone et al. 1989	66
Kisa**	Sweden	Falkenberg 1990	78
Louisville	USA	Griffiths and Wiemen 1992	53
Boston	USA	LoGerfo et al. 1992	56
Lund**	Sweden	Larsson et al. 1994a	78

*Figures refer to reduction in major amputation rate or, in the Memphis report, reduction in hospital days
**Population-based

The multidisciplinary team approach allows the patient to have adequate footwear for pressure relief and provides a possibility to choose optimal time for and type of surgery (reconstructive foot surgery, revision, resection, incision and drainage, minor amputation) in order to minimize tissue loss and prevent a major amputation. It also allows time for an optimal medical work-up prior to any surgery. This is important since the majority of these patients have multiple cardio-cerebrovascular disease accounting for the majority of complications associated with surgery.

Fewer major amputations

There are several preventive programs claiming a reduction of 50 percent or more in major amputations in patients with diabetes mellitus (Table 7). These reports are rather similar concerning the treatment strategies that have been used to implement a system of preventive and medical foot care with patient and staff education, preventive foot care, and a multidisciplinary approach to established lesions. In the Lund/Orup health care region in southern Sweden (population 0.2 million), the amputation rate has been studied continuously since 1982 (Larsson et al. 1994a; Table 8) after implementation of a multidisciplinary strategy for preventive foot care and in- and out-patient treatment of foot lesions, in close cooperation with primary health care units. In this region, the incidence of diabetes-related amputation at all levels was 19.1/100,000 inhabitants in 1982 and 9.8 in 1993. The corresponding incidences of major amputations were 16.1 and 3.6, respectively.

Table 8. Number of lower extremity amputations in diabetic patients in the Lund/Orup health care region. Final levels

	Above knee	Through knee	Below knee	Foot	Toe and single ray	Total
1982–84	21	3	57	14	17	112
1985–87	24	4	73	12	11	124
1988–90	22	5	20	15	17	79
1991–93[1]	7	8	19	7	31	72
Total	74	20	169	48	76	387

[1] 1 toe, 2 below-knee, and 1 through-knee amputation not yet healed.

This decrease was also associated with a substantial decrease in the re-amputation rate. These results emphasize the possibilities and advantages of preventive medical foot care and a multidisciplinary and multifactorial approach towards the diabetic foot. A substantial decrease in the number of major amputations has also been noted in other reports (LoGerfo et al. 1992, Pedersen et al. 1994), and ascribed mainly to the effect of vascular surgery. However, other reports do not confirm these findings (Tunis et al. 1991).

Minor versus major amputation

There is still a controversy concerning the benefit of primary minor amputation versus primary major amputation, especially regarding the long-term outcome. The advantage of primary major amputation is a lower re-amputation rate and a shorter healing time. Minor amputation is associated with a high re-amputation rate (Borssén and Lithner 1984, de Luccia et al. 1992, Valway et al. 1993) and, as a consequence, a longer wound healing time. The disadvantage of a major amputation is prolonged rehabilitation and limb-fitting problems, not to mention emotional and psychological aspects. Most studies concerning rehabilitation after major amputation include only patients admitted to a rehabilitation center. Only 50 percent of all patients undergoing major amputation are fitted with a prosthesis (Greenhalgh et al. 1988, Second European Consensus Document 1991). There are few studies concerning the outcome in this respect regarding the diabetic amputee. Moreover, the long-term outcome must be considered. Within 3 years following major amputation, diabetic patients have a mortality rate of 30–50 percent and a similar rate of second leg major amputation (Silbert 1952, Goldner 1960, Hoar and Torres 1962, Cameron et al. 1964, Ecker and Jacobs 1970, Palumbo and Melton 1985, Jernberger 1989, Levin et al. 1993). In the long-term perspective, minor amputations are associated with a lower risk than major amputations with regard to a new major amputation and have a considerably better rehabilitation potential (Larsson 1994).

There is no golden standard for the selection of a primary amputation level in diabetic patients. However, some studies have suggested certain criteria concerning the possibility of healing after a minor amputation, such as systolic toe blood pressure above 15–20 mmHg, ankle pressure above 50 mmHg, indication for amputation and age (Holstein 1984, 1985, Levin et al. 1993, Larsson et al. 1993, 1994 b, c).

In conclusion, foot lesions and the risk of amputation are a major problem in diabetic patients, and amputation is a costly solution associated with multiple and extended hospitalizations. A comprehensive treatment strategy, including preventive and medical foot care and provision of protective foot-wear, education of patients and staff, a multidisciplinary approach to established foot ulcers, strict amputation criteria and continuous registration of amputations, can bring a substantial decrease in the major amputation rate in patients with diabetes. However, the causes of amputation are very complex and many issues related to etiology, prevention, and treatment of diabetic foot lesions, and thus to lower extremity amputation, remain unresolved.

Acknowledgements

This work was supported by The Swedish Medical Research Council (Project 17 X-09509); LIC; The Swedish Society of Medicine; The Medical Faculty, University of Lund; Stiftelsen för bistånd åt vanföra i Skåne; Stiftelsen Skobranschens Utvecklingsfond; Bidrag till utvecklingarbete inom hälso- och sjukvården, MLL 1991; Statligt stimulansbidrag för habilitering och rehabilitering, MLL 1994; The Royal Physiographic Society in Lund; and the Swedish Diabetes Federation.

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